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EVALUATION OF FLUORIDE CONCENTRATION IN GROUNDWATER IN RAICHUR TALUKA, KARNATAKA STATE

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ABSTRACT

The most important natural source of water supply to the people all over the world is the groundwater. This study aims to evaluate the concentration of fluoride in the groundwater in Raichur Taluka, Raichur District. The public are not aware of the fluoride content in water. They are worried only about salt content and that; it is measured only by taste. There is no valid or recommended cost-effective household method to reduce the additional fluoride content. So it is a need to check the overall water quality and the level of fluoride concentration in the groundwater for drinking purpose. The collected sixty nine water samples were tested for physical-chemical parameters like pH, Total Dissolved Solids (TDS), Hardness, Alkalinity, Phosphate, Iron, Nitrates, Chloride and Fluoride. It was found that fluoride concentration ranged from 0.5-2.5 mg/l in the study area. This study aims to create the awareness to the public about the level of fluoride in the drinking water for taking the protective measure.

KEYWORDS: Groundwater, Water Quality Standards & Fluoride

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Original Article

1. INTRODUCTION

Groundwater is one of the most important resources affected by the increasing rate of urbanization and industrialization. The pollution keeps on increasing every day because of population. Fluoride in water exists in the dissociated form, i.e. the fluoride ion (Uma Rani et al., 2014). It is the 13th most abundant element in the earth's crust (Weinstein and Davison, 2003). If it dissolved in water it does not show signs of any color, taste or smell. Fluoride concentration in drinking water is important for public health. Fluoride is essential for dental health, bone etc. The factors which influence fluoride concentrations in natural water are geological, hydro geological, geochemical and anthropogenic. The studies indicate that high concentrations of fluoride are found in ground water. Soil is a product of the disintegration of solid bedrocks under physical and chemical reactions in which the fluorides are normally available to a considerable level (Bashir et al., 2013). Fluoride concentration in drinking water is important for human health.

The consequence of fluoride in groundwater has drawn world attention due to its impact on human physiology. The maximum allowable limit of fluoride in drinking water is specified by World Health Organization (W.H.O. 1984) is 1.5 mg/l. If the fluoride concentration is above 1.5 mg/l, that results in dental and skeletal Fluorosis. This can create serious problem when fluorides concentration exceeds above 4-8 mg/l. which leads to increase in bone density calcification of ligaments, rheumatic pain in joints and muscles along with stiffness and rigidity of the joints, bending of the vertebral column etc. (Teotia and Teotia 1994). As per the record in world around 200 million people from 25 nations have great health risks, with high fluoride in the drinking water. About

62 million people in India are at risk of developing Fluorosis from drinking high fluoride groundwater (Andezhath et al.1999.

The study conducted by Dar MA et al (2009) in Kancheepuram showed that fluoride abundance in the range of 1 to 3.24 mg/L, Pradeep Kumar et al (2011) showed ground water contamination of fluoride releases from fertilizer plants in Ennore showed fluoride concentration in the range of 0.98 to 1.04 mg/L, the study done by Balakrishnan. et al (2008) in Kancheepuram showed ground water contamination of fluoride in the range of 0.13 to 1.09mg/L.

Nowadays, the Fluoride concentration in the ground water has been increased and they affect the human health. The aim of this study is to evaluate the fluoride contamination Level in the study area, in and Raichur Taluka of Raichur District.

2. MATERIALS AND METHODS

Raichur is located at 16.2°N 77.37°E. It has an average elevation of 407 metres (1335 ft). As per the Census India 2011, Raichur Taluk has 98,867 households, population of 4,98,637 of which 2,49,556 are males and 2,49,081 are females. The population of children between ages 0-6 is 70,440 which is 14.13% of total population.

The sex-ratio of Raichur Taluk is around 998 compared to 973 which is average of Karnataka state. The literacy rate of Raichur Taluk is 55.97% out of which 64.35% males are literate and 47.57% females are literate. The total area of Raichur is 1,546 sq. km with population density of 323 per sq. km.

The prevailing climate in Raichur is known as a local steppe climate. There is not much rainfall in Raichur all year long. The average annual temperature is 27.7°C. About 713mm of precipitation falls annually. The driest month is January. There is 1 mm of precipitation in January. In September, the precipitation reaches its peak, with an average of 165 mm.

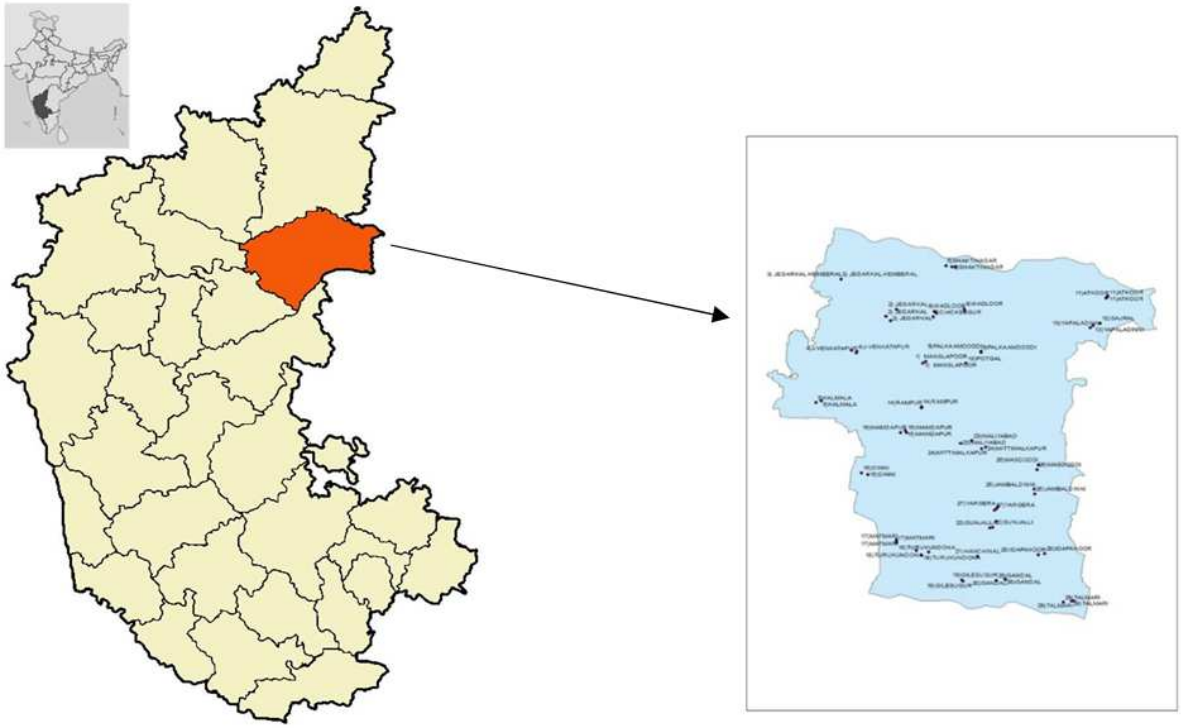

Figure 1: Raichur Taluk Study Area Map.

3. SAMPLING AND ANALYSIS

The groundwater samples were collected from sixty nine different locations and the samples are directly taken from Hand pump and bore wells. The samples are collected in well washed (washed with de-ionized water) plastic bottles and the analysis were carried out by standard methods in the laboratory.

Table 1: Location Details of Study Area

S. No.	Name of Village	Sample No	Latitude (N)	Longitude€
1	MANSLAPOOR	**S1**	**16.2491**	**77.3264**
2	MANSLAPOOR	**S2**	**16.2509**	**77.3302**
3	JEGARKAL	**S3**	**16.3027**	**77.2894**
4	JEGARKAL	**S4**	**16.3171**	**77.2957**
5	JEGARKAL	**S5**	**16.3077**	**77.2838**
6	JEGARKAL HEMBERAL	**S6**	**16.3549**	**77.2314**
7	JEGARKAL HEMBERAL	**S7**	**16.3549**	**77.2310**
8	J-VENKATAPUR	**S8**	**16.2652**	**77.2436**
9	J-VENKATAPUR	**S9**	**16.2614**	**77.2488**
10	J-VENKATAPUR	**S10**	**16.2636**	**77.2495**
11	KALMALA	**S11**	**16.2012**	**77.2079**
12	KALMALA	**S12**	**16.1989**	**77.2024**
13	SHAKTINAGAR	**S13**	**16.3707**	**77.3644**
14	SHAKTINAGAR	**S14**	**16.3707**	**77.3607**
15	SHAKTINAGAR	**S15**	**16.3721**	**77.3534**
16	CHICKSUGUR	**S16**	**16.3123**	**77.3417**
17	CHICKSUGUR	**S17**	**16.3139**	**77.3399**
18	CHICKSUGUR	**S18**	**16.3075**	**77.3385**
19	WADLOOR	**S19**	**16.3150**	**77.3752**
20	WADLOOR	**S20**	**16.3175**	**77.3748**
21	PALKAAMDODDI	**S21**	**16.2639**	**77.3945**
22	PALKAAMDODDI	**S22**	**16.2649**	**77.3944**
23	POTGAL	**S23**	**16.2486**	**77.3769**
24	ATKOOR	**S24**	**16.3336**	**77.5416**
25	ATKOOR	**S25**	**16.3310**	**77.5396**
26	ATKOOR	**S26**	**16.3320**	**77.5415**
27	GAJRAL	**S27**	**16.2990**	**77.5330**
28	YAPALADINNI	**S28**	**16.2961**	**77.5251**
29	YAPALADINNI	**S29**	**16.2933**	**77.5213**
30	RAMPUR	**S30**	**16.1923**	**77.3252**
31	RAMPUR	**S31**	**16.1937**	**77.3251**
32	MAMDAPUR	**S32**	**16.1639**	**77.3061**
33	MAMDAPUR	**S33**	**16.1614**	**77.3064**
34	MAMDAPUR	**S34**	**16.1614**	**77.3072**
35	DINNI	**S35**	**16.1080**	**77.2624**
36	MATMARI	**S36**	**16.0261**	**77.2959**
37	MATMARI	**S37**	**16.0241**	**77.2957**
38	MATMARI	**S38**	**16.0221**	**77.2957**
39	TURUKUNDONA	**S39**	**16.0121**	**77.3190**
40	TURUKUNDONA	**S40**	**16.0065**	**77.3249**
41	TURUKUNDONA	**S41**	**16.0099**	**77.3332**
42	GILESUGUR	**S42**	**15.9733**	**77.3731**
43	GILESUGUR	**S43**	**15.9751**	**77.3718**
44	GANDAL	**S44**	**15.9766**	**77.4239**
45	GANDAL	**S45**	**15.9756**	**77.4226**
46	GANDAL	**S46**	**15.9744**	**77.4124**
47	HANCHINAL	**S47**	**16.0048**	**77.3900**
48	GUNJALLI	**S48**	**16.0491**	**77.4121**

49	GUNJALLI	**S49**	**16.0410**	**77.4045**
50	GUNJALLI	**S50**	**16.0418**	**77.4028**
51	MALIYABAD	**S51**	**16.1477**	**77.3709**
52	MALIYABAD	**S52**	**16.1508**	**77.3839**
53	MITTIMALKAPUR	**S53**	**16.1409**	**77.3949**
54	MITTIMALKAPUR	**S54**	**16.1425**	**77.4001**
55	JAMBALDINNI	**S55**	**16.0895**	**77.4562**
56	JAMBALDINNI	**S56**	**16.0837**	**77.4568**
57	MASDODDI	**S57**	**16.1203**	**77.4609**
58	MASDODDI	**S58**	**16.1143**	**77.4595**
59	YARGERA	**S59**	**16.0677**	**77.4144**
60	YARGERA	**S60**	**16.0654**	**77.4126**
61	YARGERA	**S61**	**16.0634**	**77.4100**
62	IDAPANOOR	**S62**	**16.0068**	**77.4610**
63	IDAPANOOR	**S63**	**16.0072**	**77.4634**
64	IDAPANOOR	**S64**	**16.0084**	**77.4687**
65	TALMARI	**S65**	**15.9482**	**77.5021**
66	TALMARI	**S66**	**15.9485**	**77.4997**
67	TALMARI	**S67**	**15.9469**	**77.4899**
68	YEGNUR	**S68**	**16.2836**	**77.5250**
69	YEGNUR	**S69**	**16.2851**	**77.3677**

Table 2: Fluoride Concentrations in Raichur Taluka

Sample Station	Fluoride Concentration (mg/l) (Pre Monsoon)	Fluoride Concentration (mg/l) (Post Monsoon)	Sample Station	Fluoride Concentration (mg/l) (Pre Monsoon)	Fluoride Concentration (mg/l) (Post Monsoon)
S1	1.92	1.85	S36	0.69	0.67
S2	1.71	1.60	S37	0.94	0.90
S3	0.7	0.86	S38	0.78	0.95
S4	0.82	0.76	S39	0.54	0.58
S5	0.81	0.70	S40	1.51	1.41
S6	2.26	2.28	S41	0.86	0.90
S7	1.81	2.00	S42	0.82	0.88
S8	1.6	1.40	S43	0.93	0.90
S9	1.48	1.56	S44	1.30	1.00
S10	1.51	1.60	S45	0.69	0.70
S11	1.83	1.95	S46	0.74	0.80
S12	1.35	1.20	S47	1.78	1.75
S13	0.8	0.78	S48	0.72	0.67
S14	0.82	0.80	S49	0.78	0.65
S15	0.91	0.86	S50	0.82	0.66
S16	1.25	1.20	S51	1.59	1.86
S17	1.4	1.30	S52	1.42	1.30
S18	1.38	1.50	S53	1.38	1.30
S19	0.92	0.86	S54	1.36	1.20
S20	0.65	0.70	S55	1.28	1.15
S21	1.58	1.42	S56	1.32	1.25
S22	1.34	1.30	S57	0.71	0.68
S23	0.96	0.80	S58	0.93	0.87
S24	0.72	0.61	S59	0.62	0.57
S25	0.84	0.62	S60	0.72	0.60
S26	0.68	0.70	S61	0.76	0.70
S27	0.64	0.70	S62	1.41	1.30

S28	0.73	0.80	S63	1.82	1.74
S29	0.79	0.75	S64	0.96	0.80
S30	0.65	0.70	S65	0.68	0.70
S31	0.85	0.80	S66	0.71	0.56
S32	0.71	0.75	S67	0.88	0.83
S33	0.75	0.72	S68	1.11	1.14
S34	0.71	0.74	S69	1.75	1.72
S35	2.12	2.14			

Table 3: Permissible Limits of Fluoride in Drinking Water

S. No.	Name of the Organization	Permissible Limit of Fluoride (mg/l)
1	World Health Organization (WHO)	1.5
2	Bureau of Indian Standards (BIS)	1
3	Indian Council of Medical Research (ICMR)	1

Table 4: Minimum, Maximum and Mean Values of Fluoride and Other Physico-Chemical Parameters in Post-Monsoon Season

Parameters	Minimum	Maximum	Mean
pH	6.5	9	7.65
TH	50	1400	396.97
TA	190	1050	448.52
F^-	0.56	2.28	1.05
Cl^-	0	1209.62	353.59
NO_3^-	0	50	37.82
Fe^{2+}	0	0.5	0.26
NH_3	0	0.5	0.43

*All parameters are in mg/l, except pH

Table 5: Minimum, Maximum and Mean Values of Fluoride and Other Physico-Chemical Parameters in Pre-Monsoon Season

Parameters	Minimum	Maximum	Mean
pH	6.5	8.5	7.2826
TH	70	1250	420.826
TA	170	980	416.521
F^-	0.54	2.3	1.091
Cl^-	0	1250.67	386.77
NO_3^-	10	50	42.246
Fe^{2+}	0	0.5	0.2144
NH_3	0	0.5	0.259

*All parameter are in mg/l, except pH.

4. RESULTS AND DISCUSSIONS

Water is one of the most essential components for the sustenance of life on the earth. The presence of various toxic substances in the water bodies cause health hazard. Among the various sources of water, groundwater is said to be the safest water for drinking and domestic purposes. The hydro-geochemical analysis of any ground water system usually involves study of the concentration and distribution of major ions in the ground water. Small concentration of fluoride, an element in ground water has beneficial effect on human body if taken in a controlled quantity of less than 1 ppm so as to

prevent dental caries. Nevertheless, higher concentration causes serious dental and skeletal Fluorosis while present in higher concentration exceeding 1 ppm and 5 ppm respectively. In the present investigation, fluoride concentration and other physico- chemical parameters of Raichur taluka have been presented. The standard values of various physico-chemical parameters for drinking water as per BIS and WHO.

4.1 Fluoride and Other Physico-Chemical Parameters Fluoride (F^-)

The presence of fluoride (F^-) in drinking water is essential because of its physiological effects on human health. 1.5 ppm fluoride is prescribed as desirable limit in drinking water (WHO, 1984). The natural occurrence of fluoride is generally limited as most waters have a concentration less than 0.5 ppm and high fluoride concentration in ground water can be due to the presence of fluoride-bearing rocks and the degree of weathering. Fluoride is often referred to as two edged sword. Fluoride with 0.6 to 1.2 ppm is regarded as an essential constituent of drinking water mainly because of its role in prevention of dental caries, whereas concentrations more than 1.5 ppm leads to dental and skeletal Fluorosis. When the concentration of fluoride in water exceeds 10 ppm, crippling Fluorosis can be ensured (WHO,1984).

In the present investigation, fluoride values varied from a minimum of 0.54 mg/l to a maximum of 2.3 mg/1 with a mean value of 1.091 mg/1 in pre monsoon season and a minimum of 0.56mg/1 to a maximum of 2.28mg/1 with a mean value of 1.05mg/1 in post monsoon season .

4.2 pH

It is a measure of hydrogen ion concentration in solution. It is used to express the intensity of acidic or alkaline condition of a solution. It is one of the important indicators of water quality and is of great importance to living systems because both cell structure and function can be affected by even small changes in pH, high values of pH lead to scale formation in water heaters and reduce the germicidal potential of chlorine. The knowledge of pH is essential in the selection of coagulants for water purification. The acidity (low pH) will not affect the health but slightly acidic ground water is corrosive and can dissolve metals, especially copper from pipes and pumps. The corrosion can shorten the economic life of plumbing, hot water cylinders and in some cases; the dissolved metals in the water may cause illness.

In the present investigation, pH values varied from a minimum of 6.5mg/l with a mean value of 8.5mg/l with a mean value of 7.29mg/l in pre-monsoon season and for post- monsoon season pH value varied from a minimum of 6.5mg/l to a maximum of 9mg/l with a mean value of 7.65mg/l. The recommended value of pH for drinking purposes is between 6.5-8.5mg/l (BIS).

4.3 Total Hardness (TH)

Total hardness of water is the sum of concentration of alkaline earth metal cat-ions present in it. Calcium and magnesium are the principle cat-ions imparting hardness. It is defined as the concentration of multivalent metallic cat-ions in solution. At saturated conditions, the cat-ions react with anions in water to form solid precipitate.

Hardness in natural water comes mainly from the leaching of igneous rock and carbonate rocks (dolomite, calcite and limestone). Water containing the soluble salts of calcium and magnesium such as chlorides, sulphate and bicarbonates is called hard water. Generally hard water originates in the areas where thick top soil and limestone formations are present. Soft water originates in the areas where the top soil is thin and limestone formats are absent.

In the present investigation, Total Hardness values varied from a minimum of 70mg/l to a maximum of 1250 mg/1 with a mean value of 420.83mg/l in pre-monsoon season. In post-monsoon season the minimum of 50mg/l to a maximum of 1400mg/l. The mean value for post-monsoon is 396.67mg/1.

4.4 Total Alkalinity (TA)

Alkalinity of water is its acid neutralizing capacity. Alkalinity in natural water is formed due to dissolution of carbon dioxide in water. In the present investigation, the alkalinity values fluctuated between a minimum of 170mg/1 and a maximum of 980 mg/1 in pre-monsoon season. In post-monsoon season the alkalinity values ranged between 190mg/1 and 1050mg/1 and mean value ranges from 416.52mg/l and 448.52mg/l for pre-monsoon and post-monsoon seasons respectively

The BIS (1998) acceptable limit for total alkalinity drinking water is 200mg/1. Beyond this limit taste may become unpleasant. Whereas, in the absence of an alternate source of water, alkalinity in water for up to 600 mg/1 is acceptable (BIS).

4.5 Nitrate (NO_3)

Nitrate is colourless, odorless naturally occurring compound that is formed in the soil when nitrogen and oxygen combine. Nitrate is essential for growth of many plant species, including most those we eat. Yet it becomes a problem if it gets into water in excess amounts. Although it is a plant nutrient, beyond certain levels in the ground water, it is a potential threat to human health.

Decomposition of organic matters in soils, leaching of soluble chemical fertilizers, human and animal excreta, untreated effluents of Nitrogenous industries and sewage disposal are potential sources of nitrate concentration in ground water. The main source of nitrate pollution in the ground water is fertilizer application and causing elevated nitrate concentration in ground water in many areas of the world.

The consumption of nitrate in small amounts is not harmful. Nitrate can cause health problems especially those six months of age and younger. Nitrate interferes with their blood's ability to transport oxygen. This causes an oxygen deficiency, which results in a dangerous condition called "Methemoglobinemia or blue baby syndrome" in adults. The most common symptom of nitrate poisoning is bluish skin colouring, especially around the eyes and mouth. In the present study, the nitrate values ranged between a minimum of 10 mg/1 to a maximum of 50 mg/1 in pre-monsoon season. In post-monsoon season, the nitrate values ranged between 0 mg/l and 50 mg/l and mean value ranges from 42.25 mg/l and 37.82 mg/l for pre-monsoon and post-monsoon seasons respectively.

4.6 Chloride (Cl)

Chlorides occur in natural water in varying concentrations. The chloride content increases as the mineral contents increases. It is commonly found in soils and rocks. The primary source of chloride is sedimentary rocks and saline water intrusion and the minor sources are igneous rocks. High concentration of chloride makes water unpalatable and unfit for drinking and other purposes.

Chloride ion is generally present in natural water and its presence can be attributed to the dissolution of salt discharge from chemical industries, oil wells, sewage discharges, and contamination from leachates. The salty taste produced by chloride ion depends on chemical composition of the water. Chloride in shallow groundwater is a useful

indicator of contaminants from human sources compared to background concentration (e.g. urban land use, septic tanks, agricultural fields, solid waste dumping site). Chlorides in excess, imparts salty taste to water and people are not accustomed to high chloride and subjected to laxative effect.. Chlorides in reasonable concentration are not harmful to humans.

In the present study, chloride values ranged from a minimum of 0 mg/1 to a maximum of 1250.67mg/1 in pre-monsoon season. In post monsoon season its concentration was found between 0 and 1209.62 mg/1. However, the mean value for pre-monsoon season is 386.77mg/1 and for post monsoon season is 353.59mg/1. The BIS acceptable limit for chloride is 1000 mg/1.

4.7 Iron (Fe)

It is an essential and non-conservative trace element found in significant concentration in drinking water because of its abundance in the earth's crust. Iron is found in all natural waters both in oxidized (ferric) and reduced (ferrous) forms. The concentration of iron in ground water is much higher than the tolerance limit prescribed for drinking, which is responsible for the inky flavour, bitter and astringent taste to the groundwater of the region. Well water containing soluble iron remain clear while pumped out, but exposure to air causes precipitation of iron clue to oxidation, with a consequences of rusty colour and turbidity in the water .

The dissolved iron content in the groundwater of the study area varied from a minimum of 0 mg/1 to a maximum of 0.5 mg/l in pre-monsoon season. In post-monsoon season the values of iron showed a minimum of 0 to a maximum of 0.5 mg/l. The mean values of both the seasons are 0.22 and 0.26 mg/1 respectively. The BIS acceptable limit for iron is 1.0 mg/1 in drinking water. In the present study all the water samples are within the permissible limit for the drinking water standards (BIS,1998; WHO,1985). The presence of higher concentration of the iron is not suitable for processing of food, beverages, ice, dying, bleaching and many other items.

5. CONCLUSIONS

In the study area the fluoride concentration was ranged from 0.5-1.5 mg/l as suggested by BIS value. The public are not aware of the fluoride content in water. They are worried only about salt content and that, too, is measured only by taste. There is no neither valid nor recommended cost- effective household method to reduce the additional fluoride content. There are a few expensive portable water cleaning systems, like reverse osmosis, deionizers and activated alumina-based water treatment, but their efficacy has not been studied. If the people will drink the non-treated high fluoride content water, they may suffer from various dental and bone diseases and the high level of fluoride will affect the kidney and thyroid glands of the people. So it is a need to thoroughly study the groundwater before its use for domestic purposes and accordingly a suitable method can be chosen for its treatment.

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